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RubberWorld

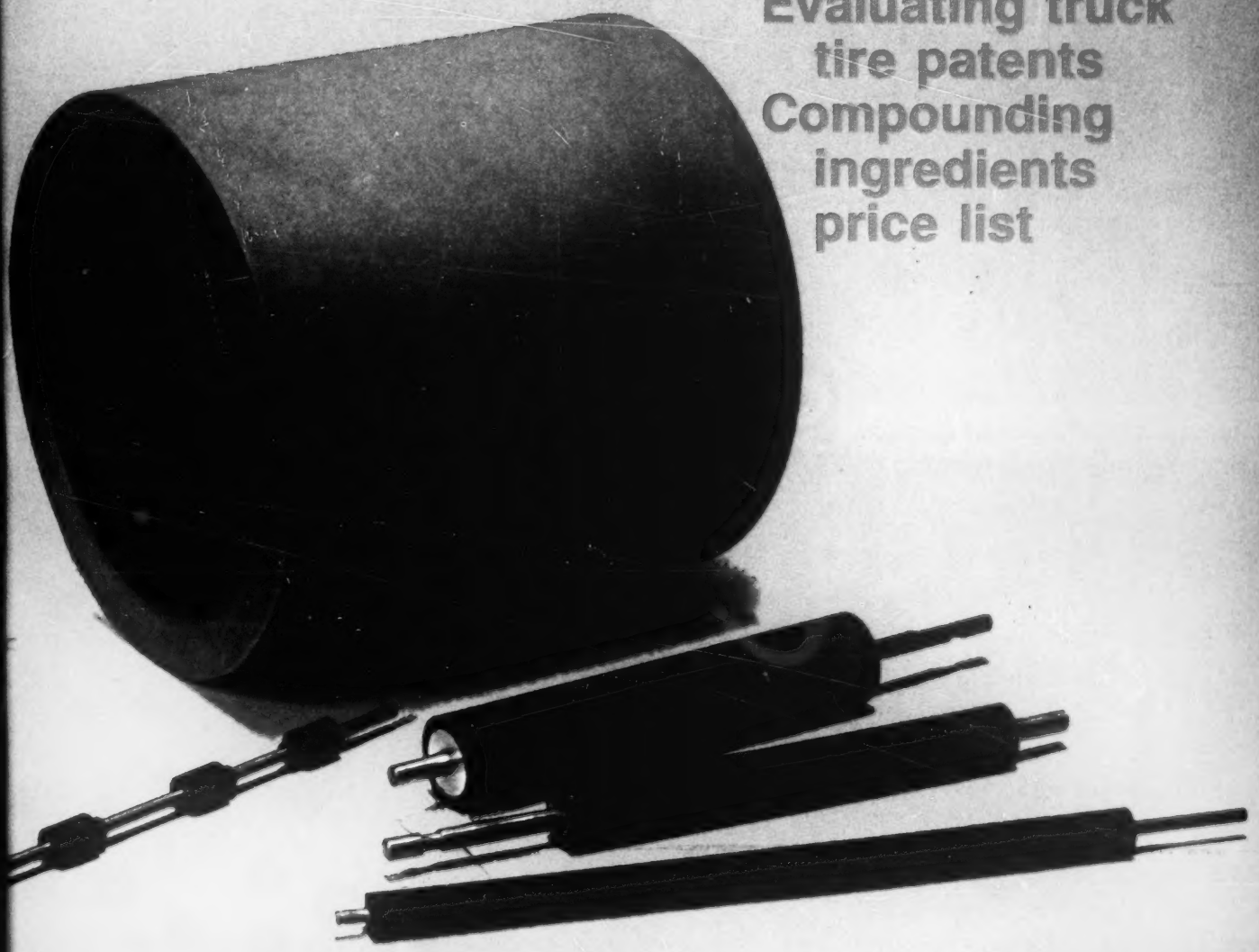
The technical service magazine for the rubber industry

Volume 201, No. 6 March 1990

New foamed elastomeric alloys

TPE production and use in the 90s

plus:
Evaluating truck tire patents
Compounding ingredients price list



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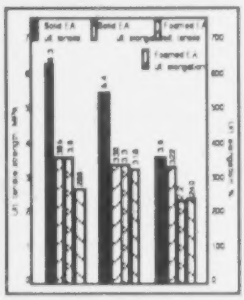

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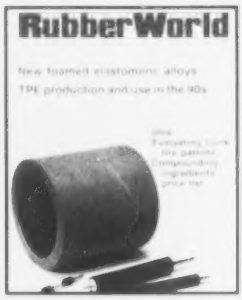

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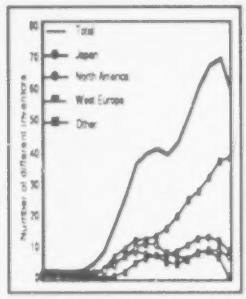

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Cover photo courtesy of Monsanto Chemical.

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The Audit Bureau

Editorial

The evolution of thermoplastic elastomers in the rubber marketplace has been interesting to observe. Although it's been almost 40 years since the introduction of the first styrenic thermoplastic elastomers, TPEs are considered a new class of material by many. This is due in part to an increase in development of new TPEs within the past several years and to the marketing of the new TPEs. With the introduction of a number of new TPEs in the 1980s came aggressive marketing to find applications. Faster cycle times, colorability, no scrap and lower finished part costs were just some of the advantages. Throw in lower density and finished product uniformity and you have a product ideal for the automotive applications of elastomers the producers claimed.

The problem was, they didn't have anybody to process it and few applications called for TPEs. Rubber product manufacturers shied away because it wasn't requested by the customer and it required an investment in new equipment. Plastics processors had the equipment but weren't selling to the markets suitable for TPE applications. The TPE suppliers then turned their attention on convincing the end user and the strategy seems to have paid off. The automotive industry naturally was the first target along with the construction market and the results look more than favorable for both the suppliers and the product manufacturers who have invested in TPE equipment. The article "TPE production and use in the 1990s" by Rudy School of R.T. Vanderbilt focuses on the expected growth of TPEs for this decade. School examines these markets and other TPE applications in his article beginning on page 15. In "New foamed EAs and other technologies," authors P.D. Agrawal and K.E. Kear of Monsanto present some specific new applications for TPEs. These deal with foamed elastomeric alloys for foamed rubber applications, roll covers and sound attenuation. As can be seen from these articles, TPEs are no longer novelties.

Another item that is no longer a novelty is pointing out some reasons for the success of Japanese companies. In the article "Evaluating truck tire patents," authors Dunn, Henderson and Smirle of Nova/Polysar show trends using computer assisted patent analysis. Although the information derived is intended to show what needs manufacturers will have it also points out where the real activity lies based on patent applications in the truck tire area. It is also a confirmation of priority placed on R&D worldwide.

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RubberWorld

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uct developed is Triax CBE/1, a flame retardant alloy to be marketed by Monsanto.

UCB Chemicals and **JSR** (Japan Synthetic Rubber) in Tokyo have entered into an agreement for the joint development of the technology and know-how belonging to the two partners in the field of specialty chemicals for electronics. Terms of the agreement call for JSR to purchase 50 percent of the shares of **UCB Electronics S.A.** UCB Electronics' production units and application laboratories in Haasrode and Drogenbos, Belgium will be expanded. The joint venture will establish a U.S. subsidiary in the first half of the year, followed by construction of a $10 million production and technical service unit later in the year.

EMS-Chemie AG of Domat/Ems, Switzerland formed a joint venture with **UBE Industries**, Tokyo, to produce lactam-12 in Japan. **UBE-EMS Ltd.** will build a plant with an annual capacity of 33 million pounds in Ube City, Japan. Start-up is scheduled for 1992. UBE will hold a 51% share, and EMS a 49% share.

Quadrax, headquartered in Portsmouth, RI, signed a definitive agreement with **Hexcel**, headquartered in Dublin, CA, to develop, manufacture and market cored structural composite panels for aerospace, naval and rail markets. The panels are made by combining a core of Hexcel metallic or non-metallic honeycomb with a facing of Quadrax's composite thermoplastic prepreg fabrics, and will be manufactured and marketed by Hexcel when commercialized. The companies will jointly work to develop new suitable bonding technology.

Polymer Transfer Services, Houston, TX, a wholly-owned subsidiary of **Shuman Plastics**, will warehouse and distribute Shuman's line of Dyna-Purge purging compounds for the cleaning of plastic processing machines.

Corporate, financial news

ACM's ownership has been consolidated from three partners to two. The company repurchased the shares of Bo Adamson, who was president, and appointed Philip Comenos chairman of the board and Richard C. Moore Jr. president. Adamson will remain associated with ACM, located in Summerville, SC, through a five year marketing consulting agreement.

A management group led by Thomas Marshall, chairman of the board and chief executive officer of **Aristech Chemical**, proposed a management-led acquisition of the company in association with **Mitsubishi** at $26 cash per share for all common shares of stock outstanding. Commitments for financing have been arranged, and the proposal is subject to completion of definitive agreements, governmental consents and approvals.

Bridgestone/Firestone will combine the 85 salaried employees of the **Firestone** office in Hamilton, Ontario, with 65 corporate employees of **Bridgestone (Canada)**, located in Mississauga, Ontario, where the combined company, **Bridgestone/Firestone Canada** will be located. Separate brand identity will be maintained for Bridgestone, Firestone and Dayton tires, the company reported.

Bridgestone/Firestone will combine the operations of **Firestone Singapore Private Ltd.** with those of the Singapore branch office of **Bridgestone**. The resulting company, **Bridgestone/Firestone Singapore Pte., Ltd.**, will unify Bridgestone's worldwide natural rubber purchasing operations, and will employ more than 20 people. Bridgestone's Singapore office will remain open through June to finish outstanding business.

Du Pont increased the price of neoprene synthetic rubber in North America by 8 cents per pound, effective February 1. The hike, 4 to 6 percent for all grades of dry and latex neoprene, is attributable to cost increases.

Engelhard said it will sell certain businesses as part of a major restructuring plan. The businesses to be sold include its metal joining and crystals, and electronics operations. The company will also restructure ongoing operations, and anticipates reduction of about 500 salaried jobs, in an effort to reduce its annual operating expenses by $30 million or more.

Firestone Industrial Products will phase out production of custom molded goods at its plant in Noblesville, IN, by August, and instead will focus on production of air springs for use in the transportation and manufacturing industries. The company will consolidate and move production of heavy duty air springs into the remaining manufac-

RMA tire report - November
(figures in thousands of units)

Passenger tires	**YTD '89**	**YTD '88**	**% change**
Shipments			
original equipment	48,153	49,863	-3.4
radial	42,009	42,552	-1.3
replacement	142,062	143,255	-0.8
radial	135,317	134,166	0.9
export	11,621	8,655	34.3
radial	10,849	7,736	40.2
total	201,836	201,773	-
radial	188,175	184,453	2.0
Production	162,859	161,228	1.0
radial	152,576	147,082	3.7
Truck & bus tires			
Shipments			
original equipment	7,662	8,135	-5.8
radial	6,394	6,090	5.0
replacement	32,707	31,250	4.7
radial	19,636	18,477	6.3
export	3,299	3,017	9.4
radial	2,461	2,344	5.0
total	43,668	42,403	3.0
radial	28,492	26,910	5.9
Production	35,292	34,022	3.7
radial	23,756	21,112	12.5

turing space at the Noblesville site. The current work force of 520 hourly and 230 salaried will be reduced by about 200 and 50 respectively. The corporate headquarters staff of about 40 will be relocated from the plant complex to a location yet to be determined, but reported to be somewhere near Indianapolis.

Goodyear will cut back production of bias light truck tires, specialty tires and some bias medium truck tires, about 6,000 tires per day overall, at its Gadsden, AL plant, affecting 500 salaried and hourly jobs. The company said the decision was based on a falling bias truck tire market resulting from the rise in demand for radials. The reduced production requirements will be consolidated at two other Goodyear plants in Topeka, KS, and Freeport, IL.

Standard Products will close its Lexington, SC plant due to the slowdown in the automotive industry and significantly decreased demand from its only customer, **General Motors**. The 52,000 square foot plant employs 130 hourly and 22 salaried workers and manufactures plastic moldings for doors and windows.

RMA rubber report through October (figures in metric tons)

	YTD 1989	YTD 1988	% chg.
Total new rubber			
New rubber available	2,962,264	2,854,335	3.8
Imports	1,050,148	913,792	14.9
Exports	422,239	479,734	-12.0
Apparent consumption	2,499,590	2,390,344	4.6
Total natural rubber			
Imports	768,456	701,692	9.5
Exports	27,593	42,108	-34.5
Apparent consumption	751,263	707,661	6.2
Total synthetic rubber			
Production	1,912,116	1,940,543	-1.5
Imports	281,692	212,100	32.8
Exports	394,646	437,626	-9.8
Apparent consumption	1,748,323	1,682,676	3.9
Total SBR			
Production	741,066	756,770	-2.1
Imports	94,008	75,510	24.5
Exports	149,812	161,498	-7.2
Apparent consumption	669,455	645,729	3.7
Total nitrile			
Production	55,277	62,857	-12.1
Imports	13,894	13,984	-.6
Exports	15,912	12,952	22.8
Apparent consumption	52,486	63,215	-17.0
Polybutadiene			
Production	345,330	337,097	2.4
Imports	56,496	65,133	-13.3
Exports	68,487	54,330	26.1
Apparent consumption	316,544	338,317	-6.4
Ethylene-propylene			
Production	220,986	221,773	-.4
Imports	30,156	10,933	175.8
Exports	44,114	42,522	3.7
Apparent consumption	192,503	191,232	.7
Butyl, polychloroprene, polyisoprene, silicone and other synthetic elastomers			
Production	549,458	562,045	-2.2
Imports	87,138	46,540	87.2
Exports	116,321	166,324	-30.1
Apparent consumption	517,335	444,170	16.5

Markets, news

An influx of manufacturers from other nations are bringing their business to Indonesia. This, combined with newly formed joint ventures, is contributing to the country's growth in the footwear exporting industry. Many new plants springing up in Indonesia are joint ventures with Korea, Taiwanese or Hong Kong companies, proving a trend which sees an increase in foreign and domestic investments in the shoe industry. The joint ventures together exported $57 million worth of rubber-soled running and other sport shoes in 1988, up from just $10 million in 1987, according to information obtained from an agent of the Republic of Indonesia. Foreign investment has risen quickly in the Indonesian shoe market, from just two projects in 1987, to 17 in 1988, and another 15 starting in the first half of 1989. This represents a total of $238 million in shoe-related investments in Indonesia in the last two and a half years. In addition, 26 domestically-owned projects contributed $137 million to the figure.

Results of a survey of rubber manufacturers in the European Community undertaken by the rubber manufacturers associations in Belgium, France, Germany, Italy, The Netherlands, Spain and the UK revealed that processors would like to see improvements in purity, pollution, processability, physical properties and packaging. Respondents declared that quality standards for raw materials, including NR, must be maintained and improved; that there is a need for more communication between rubber producers and consumers to develop test methods, ranges of tolerances, etc., that can all be agreed upon; that purity problems would be improved if the collection and preparation of NR could be improved and standardized; to improve packaging, wood use in pallets and crates should be eliminated, packaging specifications from years ago should be revised, the gauge and wrapping material should be consistent within the specification, and bales should be uniform and production dated - with the grade and origin made easily identifiable.

Correction

The cover photo on the February 1990 issue of *Rubber World* was supplied by Akzo Chemicals Inc., not the company mentioned on the contents page.

Evaluating truck tire patents

by J.R. Dunn, J.F. Henderson and J. Smirle, Nova/Polysar

Assessment of trends and priority needs in an industry is an important feature in planning short and long term research by fabricators and by those who supply them with raw materials.

Trends may be determined in several ways, including:

- Discussion with end users, fabricators and their suppliers;
- Study of trade and technical literature;
- Evaluation of patents.

The three routes are complementary and each can be used to confirm conclusions drawn using the others. Direct discussion may not reveal a need which a company believes it can fully meet. Furthermore, if a company feels it can meet a major need, it may choose not to publicize the discovery or invention in the literature but it may find it advisable to protect it with patents. Consequently, patents are often the first indicator of emerging needs and major inventions, although it must be realized that some companies (especially those in Japan) have a policy of patenting most of their research while others (especially those in West Europe) appear to patent only those inventions that are valuable and are liable to be copied.

Until recently, the systematic study of patents on a broad topic would have been tedious and time consuming. The task has been simplified by:

- The availability of commercial data bases;
- The availability of sophisticated personal computers and programs for rapid data analysis.

In this study, patents on truck, heavy duty, farm and aircraft tires, applied for since the early 1970s, have been evaluated in order to determine how patent activity has grown in different geographical areas, the type and parts of the tire involved, the method used to improve the tire and the properties in which improvement has been sought.

Patent selection

Patents concerning truck and other heavy duty tires abstracted in the Derwent World Patent Index between 1975 and 1988 were scanned for relevance. These abstracts include a number of applications that were made prior to 1975. This provided a total of 552 inventions described in patent applications which have subsequently resulted in patents in 470 instances and Japanese kokais in the remaining 82 instances. The Japanese kokais are publications of patent applications in Japan which may or may not eventually result in an issued patent.

Table 1 - technical approach (primary invention)

B - Novel method of fabrication
C - Novel compounding ingredient(s) (e.g. reinforcing agent, plasticizer, antioxidant accelerator, curative, etc.)
D - Novel design of all or part of the tire
M - Novel material other than polymer or rubber composition (e.g. tire cord or belting material or coating)
P - Novel or modified polymer or method of polymerization
R - Novel blend of polymers

Table 2 - broad field qualifiers

01 Type of tire
02 Part of tire
03 Type of material (non-rubber)
04 Design details
05 Compounding highlights
06 Type of polymer
07 Physical properties
08 Method of fabrication

Data entry

The data from the selected abstracts was analyzed using a Macintosh SE computer and a relational database program written in Omnis 3 software. The information entered for each invention included:

- Key identifier (country and identification number of initial filing) - a unique means of identifying basic patent applications and the resulting patents;
- Priority date;
- Derwent World Patent Index assession number;
- Assignee;
- Number of countries in which applications were filed;
- Number of U.S. patents arising from the application;
- Names of inventors (if available) ;
- An alphabetic code to identify the principal method or "technical approach" by which the tire is improved (see table 1);
- A series of "qualifiers" or five digit codes which permit the entry of extensive additional information. The first two digits (see table 2) indicate a broad field of information while the last three digits are used to indicate the detail within the broad field.

Data analysis

For analysis the relevant information was exposed to a spreadsheet in Microsoft Excel software. Graphs and pie charts were prepared with the aid of Cricket Graph software. The graphical data have been smoothed using three year by three year moving averages.

Determination of citations

In the U.S. patent system, prior art must be cited by the examiner on the front page of the patent. The number of citations a patent receives is a measure of its perceived importance - especially if it has been issued relatively recently and has been cited several times. In order to obtain information on citations, abstracts of the U.S. patents identified were sought from the Claims/U.S. Patent Database and the number of citations for each U.S. patent was included in our database.

Breakdown of information by company

Of the 470 applications resulting in patents on truck and heavy duty tires, 88 originated from five U.S. companies with 42 of these originating from Goodyear. The 88 applications resulted in 70 U.S. patents, some of them leading to more than one U.S. patent as indicated by 11 applications

for BFGoodrich resulting in 13 U.S. patents.

Of the 470 patents, 81 originated from the five major European tire companies and Bayer, a synthetic rubber and rubber chemicals producer. Thirty-seven of these applications resulted in U.S. patents.

Of the 470 patents, 166 originated from four Japanese companies - 108 of them from Bridgestone. In addition, 64 of the 82 kokais originated from these companies. The Japanese applications resulted in 99 U.S. patents, i.e. more U.S. truck tire patents originated from the four Japanese companies than from the five major U.S. companies and Bridgestone obtained twice as many U.S. truck tire patents as any other company. The large number of U.S. truck tire patents of Japanese origin is surprising. In the 1984-86 period, 18% of all U.S. patents originated in Japan and 21% in Western Europe. Of the U.S. truck tire patents from major companies, over a longer period when the Japanese contribution would be expected to be less, 45% originated in Japan and 17% In Western Europe. This indicates a very strong Japanese interest in the U.S. truck tire market.

The average number of countries of filing is shown in figure 1. Although Japanese companies obtain many patents, they hold them in very few countries - frequently Japan and U.S. only. This may reflect the fact that Japanese companies have, until recently, concentrated on the Japanese and U.S. markets. U.S. companies, especially those which have, or have had, international organizations, file more broadly while European companies file very broadly. especially in Europe.

Figure 1 - top 15 companies (world): Average numbers of countries in which applications were filed

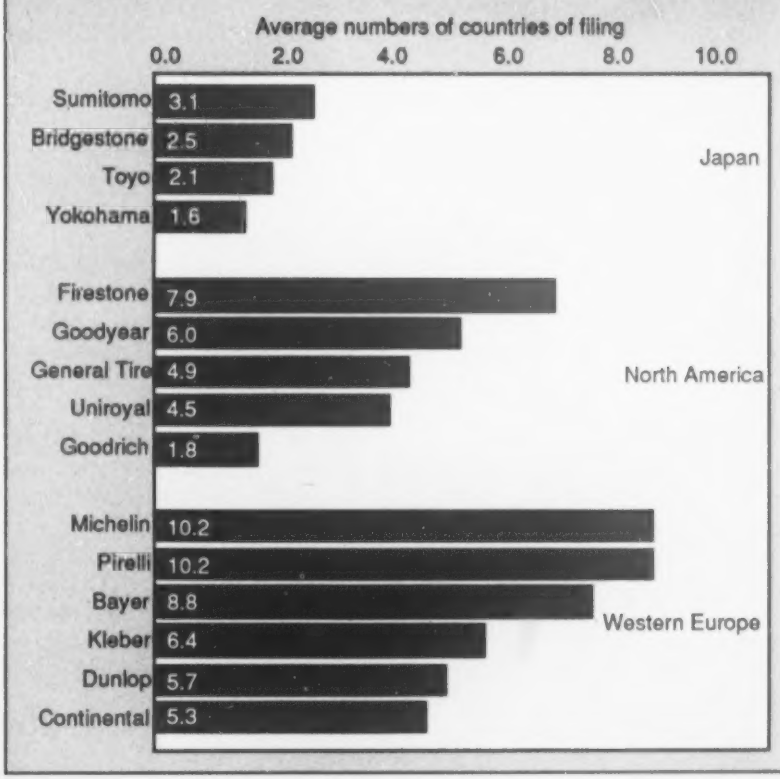
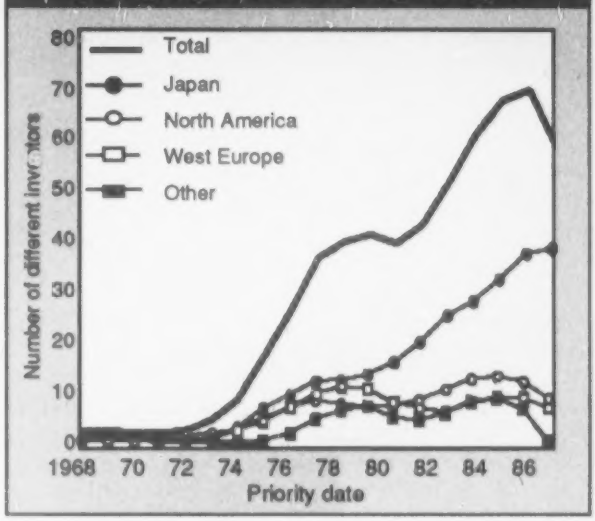


Figure 2 - number of different inventors per year by region: 3 x 3 moving averages



Bridgestone, Goodyear and Michelin are the three companies having the largest number of truck tire patents in the U.S. patent system.

Number of different inventors per year

The number of different inventors identified has grown steadily since 1972 (figure 2). It should be noted that Derwent World Patent Index began to identify inventors in 1978. The growth in identifiable inventors since 1978 is attributable to the growth in Japanese activity. The downturn in inventors in 1986 arose from a decline everywhere except in Japan, while a decline around 1980 was attributable to a decrease in West European inventors.

Tire types

The amount of activity on each tire type, divided in four time periods, between 1966 and 1986, is shown in table 3. Current interest appears to be mostly on truck and bus tires. Activity on earthmover tires was greatest between 1972 and 1976 and activity on off-the-road tires peaked between 1977 and 1981.

Insofar as there have been claims regarding special properties, there appears to be current interest in "all weather" and run flat or safety performance in truck and heavy duty tires.

Technical approach

The number of patents and kokais devoted to each technical approach is: B - 78(13); C - 28(20); D - 291(17); M - 37(18); P - 18(5); R - 18(9). About 60% of the patents concern changes in design and almost 20% concern changes in manufacturing. For the purposes of this article the term

Table 3 - tire types by 5-year period

	Number of patents (kokais) in time period				
Types of tire	*1966-71*	*1972-76*	*1977-81*	*1982-86*	*Total*
Truck/bus	9 (0)	34 (1)	61 (14)	121 (36)	225 (51)
Heavy duty	10 (0)	31 (0)	78 (6)	81 (20)	200 (26)
Off-the-road	3 (0)	25 (0)	32 (2)	21 (3)	81 (5)
Farm/agriculture	5 (0)	16 (1)	20 (1)	20 (3)	61 (5)
Earthmover	1 (0)	12 (0)	6 (0)	4 (0)	23 (0)
Aircraft	1 (0)	8 (0)	7 (3)	13 (5)	29 (8)
Fork lift solid	-	8 (0)	5 (2)	7 (0)	20 (2)
All weather	-	1 (0)	-	5 (2)	6 (2)
Winter	-	3 (0)	1 (0)	-	4 (0)
Runflat/safety	-	4 (0)	4 (1)	8 (0)	16 (1)
Self seal	-	1 (0)	1 (0)	-	2 (0)

'design' includes both the design of individual components (such as the tread) and the configuration of components within the tire; the term 'manufacturing' covers the equipment and process of manufacturing. Comparatively few patents concentrate on compounding or novel polymers or blends.

It can be seen that over 25% of the kokais concern compounding and 12.5% of the kokais concern rubber blends, which is a much higher percentage than that of granted patents that apply to these topics. Inventions in such areas may frequently be regarded as 'obvious' by a patent examiner.

Polymer types specified in truck tire patents

The polymers and blends referred to in the four time frames from 1966 to 1986 show that most of the activity on polymers has been in the 1982-86 period. No polymer has emerged as the center of attention and there is no evidence that specialty polymers are being developed for truck tires. This appears to be a need to which polymer producers have been reluctant to pay attention.

Citations

Of the 470 applications on which patents have been granted, only 25 have been cited five or more times. Since 1978 only about one patent per year has been cited five or more times. Patents filed in the mid 1970s include two or three each year which are highly cited - many of them were on design - but around 1975, some highly cited patents on novel rubbers or blends were issued. The low citing frequency suggests that most inventions pertaining to truck tires have been incremental, often building on basic inventions made in passenger tires.

Breakdown of activity by geographic region

Comparison of activity by region, using all patents, is made difficult by the fact that the patent information is issued in some countries prior to examination and examination is more demanding in certain countries. This problem may be overcome by making comparisons in a single system, e.g. U.S. patents, but this practice gives undue weighting to patents of U.S. origin. However, it is generally more meaningful to examine trends and new directions in patent activity rather than the number of patents being issued in a region or country.

Since 1977, growth in activity on truck tires can be accounted for by work in Japan. While activity elsewhere shows a tendency to decrease, that in Japan appears to be growing unabated.

Concerning the activity by geographic region with kokais excluded, the story remains much the same. Japanese activity on issued patents continues to increase. It showed a shallow dip in the early 1980s. With the effect of kokais excluded, the fall-off in total activity, due to decline outside of Japan, is more apparent.

The geographical distribution of activity in a single system (U.S. patents) shows the number of patents of U.S. origin per year declined between 1977 and 1980, increased steeply until 1983 and then increased more slowly. The number of U.S. patents of Japanese origin per year levelled off in 1977 but surpassed the number of patents of U.S. origin in that year and continued to do so.

Activity on truck tires by technical approach

Not only are more than half the total patents and kokais the result of design innovations, but the number arising from design changes is growing more rapidly than changes related to compounds or polymers. North American activity has been variable with a sharp dip around 1980, reflecting the recession and a steep drop between 1984 and 1986, presumably due to take-over threats and mergers in the North American industry. It is design activity which is cyclical. Activity on novel polymers and blends peaked around 1975 and has tended to grow from a low point around 1980.

West European activity peaked around 1977 and has always been mostly on design. Japanese activity, although predominantly on design, showed a peak in activity on novel polymers and blends around 1981 and now indicates some concentration on compounding.

Activity on truck tire treads

Of 552 patents and kokais on truck and heavy duty tires, 158 make specific reference to the tire tread. In truck tires, as in passenger tires, improvements in the tread are the primary concern of the tire industry.

Activity on truck tire treads in Japan has been growing since 1974, although the pace of growth has slackened somewhat recently. West European activity on treads has kept a steady pace around two patents per year while U.S. activity peaked in the middle 1980s and declined sharply after 1984.

Until about 1975, all activity on truck tire treads involved changes in design. Activity on novel polymers and blends peaked around 1982 and has been overtaken by activity on compounding.

Activity on truck tire sidewalls

There has been much less activity on truck tire sidewalls with a total of only 19 patents and kokais. The overall pattern is unusual since activity peaked around 1978 and is now very small. U.S. activity peaked in the mid 1970s and Japanese activity peaked around 1981. Overall, European activity has been dominant with a peak around 1983, but

current activity appears to be only in Japan.

Design changes to improve the sidewall peaked around 1978 and 1983-84. What little activity there has been on novel polymers or blends peaked around 1981.

Physical properties

The physical properties referred to in truck and heavy duty tire patents are tabulated in four time intervals between 1966 and 1986 in table 4.

The broad term durability is used in 144 of 470 patents and improvements in durability are clearly growing in importance.

105 patents and 16 kokais refer to a number of strength and failure related properties, the single most important being delamination resistance which was the subject of several patents in the 1977-81 period.

Wear or abrasion resistance was the subject of 99 patents and 18 kokais with the greatest activity in the 1982-86 period. This includes 49 patents referring to uneven wear of truck tires of which 31 were applied for between 1982 and 1986.

Skid resistance, grip and traction have also been of major and growing interest, although the increase in activity between 1977-81 and 1982-86 was not as great as for that on wear. Interest in wet skid resistance was very strong in the 1982-86 period. The activity on snow traction is also of interest. It has not been large but it has taken place almost exclusively since 1982.

There have been many patents referring to dynamic properties with indications that interest is growing. In particular, most of the activity on rolling resistance and truck tire noise has been in the 1982-86 period.

Surprisingly, there have been very few truck tire patents concerning polymer processability or liner impermeability.

Durability

Most of the increase in activity on truck tire durability has been, and continues to be, in Japan. Activity has been steady in Western Europe since the mid1970s, while that in North America has increased very slowly.

Wear resistance

Most of the increase in work on wear resistance since the mid 1970s has been in Japan. There has been a recent slackening of issued patents but growth in the issuing of kokais on the topic continues. Interest in wear in North America has been apparent since the late 1970s but, in contrast with Japan, the level of activity has been steady or declining since 1982.

Interest in uneven wear follows a similar pattern. However, worldwide interest seems to be declining and that in Japan is no longer growing. West European activity peaked in the mid 1970s while that in North America grew in the early 1980s and is now declining. It appears that uneven wear may be less of a problem as radial truck tires become more widely accepted.

Table 4 - physical properties by 5-year period

	Number of patents (kokais) in time period				
Property	*1966-71*	*1972-76*	*1977-81*	*1982-86*	*Total*
Physical properties	4 (0)	28 (1)	36 (4)	37 (11)	105 (16)
Strength	-	4 (0)	3 (0)	3 (6)	10 (6)
Cut resistance	-	9 (0)	2 (2)	4 (3)	15 (5)
Crack resistance	-	1 (1)	7 (1)	7 (1)	15 (3)
Cut/crack growth resistance	-	-	-	5 (0)	5 (0)
Delamination resistance	-	5 (0)	15 (1)	5 (1)	25 (2)
Green strength	-	2 (0)	1 (0)	3 (0)	6 (0)
Wear/abrasion resistance	4 (0)	18 (0)	27 (5)	50 (13)	99 (18)
Uneven wear resistance	1 (0)	4 (0)	13(0)	31 (1)	49 (1)
Skid resistance/grip/traction	3 (0)	13 (0)	25 (0)	36 (4)	77 (4)
Wet skid resistance	-	3 (0)	4 (0)	19 (2)	26 (2)
Ice traction	-	-	1 (0)	0 (2)	1 (2)
Snow traction	1 (0)	-	-	5 (1)	6 (1)
Dynamic properties	3 (0)	5 (0)	21 (6)	34 (13)	63 (19)
Rolling resistance	-	-	5 (3)	13 (3)	18 (6)
Low heat build up	2 (0)	4 (0)	8 (2)	9 (6)	23 (8)
Vibration damping	-	-	7 (0)	7 (0)	14 (0)
Noise reduction	-	-	1 (0)	4 (2)	5 (2)
Durability	5 (0)	28 (0)	39 (7)	72 (21)	144 (28)
Heat resistance	-	3 (0)	5 (1)	4 (3)	12 (4)
Ozone resistance	-	-	0 (1)	0 (1)	0 (2)
Puncture resistance	-	1 (0)	7 (0)	2 (0)	10 (0)
Adhesion	1 (0)	2 (0)	7 (2)	8 (2)	18 (4)
Processability	-	1 (1)	1 (0)	2 (1)	4 (2)
Low permeability	-	1 (0)	1 (0)	0 (2)	2 (2)

Skid resistance

Skid resistance of truck tires is receiving little attention currently, outside of Japan, and activity there may have peaked also. Skid resistance received attention in Western Europe in the mid 1970s and some in North America in the early 1980s.

Since about 1977, almost all patents concerning wet skid resistance of truck tires have originated in Japan, although since the early 1980s there has been increased interest in Western Europe.

Dynamic properties

There is considerable growth in the number of patent applications in Japan concerning dynamic properties of truck tires. Much of this growth is in the number of kokais. North American activity has been very low except in the early 1980s, while that in Europe has maintained a steady pace.

Much of the work on truck tire rolling resistance has been done in Japan and almost all of the recent work has been there. Activity in both Western Europe and North America peaked around 1983. The number of Japanese patents concerning heat build-up has stayed steady since the mid-1970s, but the number of kokais con-

Table 5 - topics of interest in truck tire patents

Topic	*Emerg.*	*Maximum*	*Trend setter*
Tread	1972	1985	W. Europe
Sidewall	1973	1978	N. America
Durability	1971	Increasing	All
Wear resistance	1970	1985	W. Europe
Uneven wear	1974	1984	Japan/N. Am.
Skid resistance	1971	1984	W. Europe
Wet skid resistance	1978	Increasing	Japan
Dynamic properties	1972	Increasing	Japan
Rolling resistance	1976	Increasing	W. Europe
Low heat build up	1972	Increasing	N. America
Delamination	1972	1979	W. Europe

tinues to grow. North American interest in heat build-up has been very low.

Delamination resistance

As noted earlier, concern regarding delamination resistance peaked around 1979-80. The problem was addressed in Western Europe around 1976, and in Japan interest peaked around 1980 but work continued until the mid 1980s. This has not been a topic of interest in North America.

Summary and conclusions

Computer assisted patent analysis has provided insight into trends and needs in truck and heavy duty tires, where those concerns are being addressed and by what methods.

The number of patents filed on truck tires is increasing each year, largely because of applications of Japanese origin. The number of inventors in Japan is also increasing rapidly. The number of truck tire patents granted annually to North American and West European companies remains about the same. The number of patents filed by a West European company is relatively small, but they are filed and issued in a large number of countries.

Many of the truck tire patents concern truck tire tread, and only a few refer to sidewall. Treadwear, and specifically uneven wear, is a topic of major interest. Skid resistance has been a major topic but, so far as truck tires are concerned, interest may be waning. There has been some work on winter traction in the last few years, as well as work on tire noise. Heat build-up and, latterly, rolling resistance are also topics of interest. A more general topic of major interest is tire durability.

The date and region of origin, together with the year of maximum activity of inventions on a number of topics related to truck tires, are summarized in table 5. There are five topics which are currently increasing in importance, namely: durability, wet skid resistance, dynamic properties, rolling resistance and heat build-up.

There have been relatively few patents regarding novel polymers or polymer blends for use in truck or heavy duty tires. NR, alone or blended with BR of SBR, remains the elastomer of choice.

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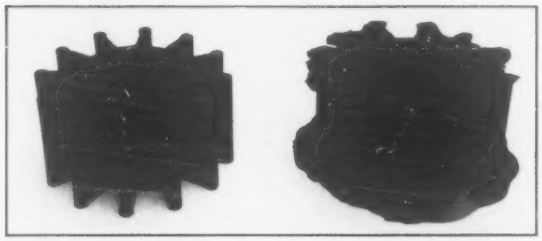

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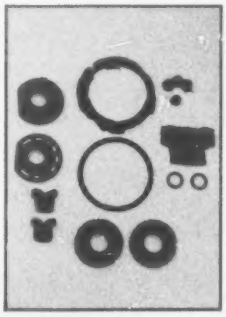

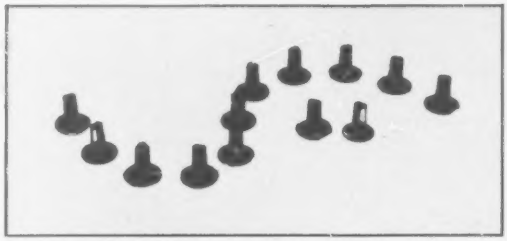

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